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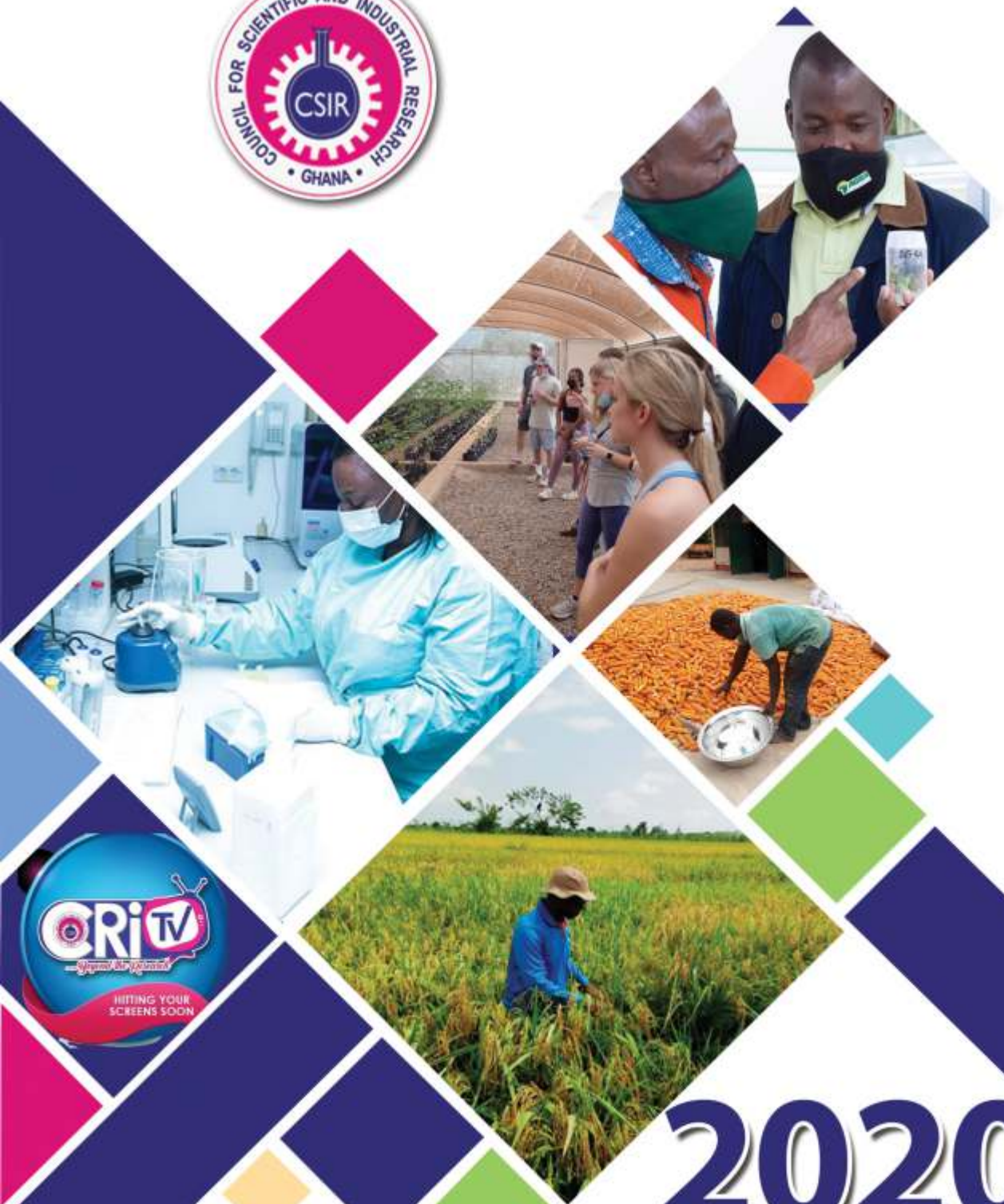

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2020 ANNUAL REPORT

CSIR-CROPS RESEARCH INSTITUTE

2020

ANNUAL REPORT

ISSN: 2590-9606

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Layout and Design: 2P KONCEPT (0246774334)

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LIST OF PLATES

List Of Acronyms

ATF	African Agricultural Technology Foundation
ACMV	African Cassava Mosaic Virus
AGRA	Alliance for a Green Revolution in Africa.
AU	The African Union
BCR	Benefit-Cost Ratio
BMGF	The Bill & Melinda Gates Foundation
BPA	Bui Power Authority
CABI	Centre for Agriculture and Bioscience International
CGIAR	Consortium of International Agricultural Resarch Centres
CGM	Cassava Green Mite
CIAT	The International Centre for Tropical Agriculture
CMD	Cassava Mosaic Disease
CRI	Crops Research Institute
CSIR	Council for Scientific And Industrial Research
DBM	Diamondback moth
DNA	Deoxyribonucleic Acid
EiB	Excellence in Breeding
EU	The European Union
FAW	Fall Armyworm
GIDA	Ghana Irrigation Development Authority
GPS	Global Positioning System
IGF	Internally Generated Funds
IITA	The International Institute of Tropical Agriculture
IPM	Integrated Plant Management
JMS	Jadam Microorganism Solution
KAFACI	The Korea-Africa Food & Agriculture Cooperation Initiative
KOPIA	Korea Program for International Cooperation in Agricultural Technology
MAG	Modernizing Agriculture In Ghana
MAS	Marker-assisted selection
MBC	Microbial Biomass Carbon
MOFA	Ministry of Food and Agriculture

NCM ELISA	Nitrocellulose Membranes Enzyme-Linked Immunosorbent Assays
NGO	Non-governmental Organization
NVRRC	National Variety Release and Registration Committee
PABRA	Pan-Africa Bean Research Alliance
PAPs	Project Affected Persons
PAWC	Plant Available Water Capacity
PERD	Planting for Export and Rural Development
PFJ	Planting for Food & Jobs
QC	Quality Control
QTL	Quantitative Trait Locus
RELC	Research-Extension-Farmer Linkage Committee
RGA	Rapid Generation Advance
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
RYMV	Rice Yellow Mottle virus
SARI	Savanna Agricultural Research Institute
SNP	Single Nucleotide Polymorphism
SPVD	Sweet Potato Virus Disease
TIBS	Temporary Immersion Bioreactor System
UK	United Kingdom
US	United States
WAVE	West African Virus Epidemiology
WFP	World Food Programme

FOREWORD

Greetings.

We are glad to present to you an overview of our research activities for the year 2020.

To say the year 2020 was a challenging one would be a huge understatement as the entire world was hit with the covid-19 pandemic and its attendant restrictions and protocols affecting all spheres of life including agricultural research activities. Nonetheless, as a Centre of Excellence, we strive to achieve perfection and as such we conducted research activities even in the middle of the pandemic. Even when face to face interactions with our farmers and various stakeholders were impossible, we employed various innovative means including the use of technologies to meet our targets.

As is usually the case, most of our research activities were centred on our mandate crops such as cereals, legumes, horticultural crops, tropical fruits and vegetables, roots and tuber crops and industrial crops. Various activities were undertaken to increase agricultural productivity and better the lot of our stakeholders and the general public.Even though a number of research projects were either put on hold or not started at all, due to the pandemic, we ensured that the few activities we engaged in, realized the maximum impact and yielded best results for our various stakeholders.

Funding is a major component of all our agricultural research activities and we are grateful to all our donors and sponsors for always providing us with the needed financial support. We would literally have nothing to report on, but for their support. We believe the quality of our very qualified and overly dedicated human resource has always been a major contributing factor in our success. Nonetheless, we keep encouraging staff members to build their capacities through further training. Additionally, the Institute continues to make training opportunities available to all staff. We continue to improve on our existing infrastructure as well as increasing commercialization activities in order to generate more internally generated funds (IGF) to complement dwindling donor support.

We are eternally grateful to all those whose contribution, support and criticisms have brought us this far. Our appreciation also goes to our very hardworking and committed staff for enduring the long hours in the offices and on the fields. Together we've made progress towards attaining our vision and we hope to continue working hard as we take advantage of every opportunity presented to us.

Thank you.

ACKNOWLEDGEMENTS

We owe our continuous success to several groups, institutions and individuals who have contributed immensely to all the successes the CSIR-Crops Research Institute has chalked over the years. To all those people, we say a huge "Thank You" and it is our prayer that the coming years bring us even more successes together.

Our heartfelt gratitude goes to our partners, collaborators and donors for being by our side despite the untold hardships brought on global economies by the covid-19 pandemic. During a period on uncertainty when most donors were skeptical about supporting agricultural research especially on the African continent, our most loyal donors kept faith with us and continued to fund our activities. For this, we are eternally grateful. It is our hope that we will continue to work together for a long time to achieve all our different aspirations.

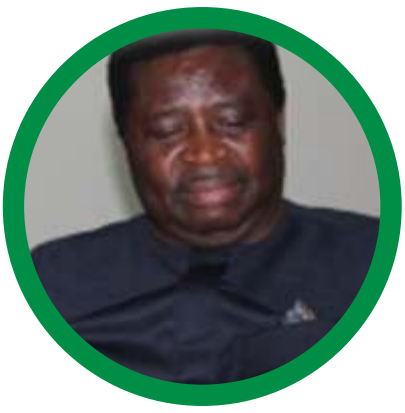
In 2020, we were fortunate to receive support from partners such as the Modernizing Agriculture in Ghana (MAG) project, Solidaridad, the Alliance for a Green Revolution Africa (AGRA), the Bill/Melinda Gates Foundation (BMGF), KAFACI International, the International Institute of Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT), the Centre for Agriculture and Bioscience International (CABI), the World Food Programme (WFP), the African Union (AU), the European Union (EU) among many others.

As the largest of the thirteen (13) institutes of the CSIR, we also collaborate with all our "sister" institutes as well as universities, non-governmental organisations (NGOs), civil society, farmers, ministries, and other research institutions, all of whom we owe a great deal of indebtedness.

To paraphrase the popular quote by the famous English scientist, Sir Isaac Newton, “If we have “seen further”, it is because we have been “standing” on the shoulders of our “giant” management board members who work tirelessly to push the Institute to greater heights. To this end, we say kudos to Dr. Abu Sakara Forster, Nana Fobi Kropa III, Mr. Theophilus Owusu, Mrs Janet Gyimah Kessie, Mr. Emmanuel Brako, Alhaji Prof. Mohammed Moro Buri, and Prof. Moses B. Mochiah for all the various roles they have played. We're glad to have you all in our corner.

Finally, what can we say to our most dedicated and committed scientists, technical and support staff who had to endure covid-19 restrictions and protocols all year round but somehow managed to produce results and achieve set targets. We say a big “ayekoo” to you all. Here's to many more fruitful years ahead.

God richly bless us all.



OUR PROFILE

Established in 1964, the CSIR-Crops Research Institute (CSIR-CRI) is the largest of the thirteen (13) institutes of the Council for Scientific and Industrial Research (CSIR) of Ghana and is the foremost national science and technology organization in Ghana. The Institute provides innovative research and research-related services to the general public as well as other institutions.

The CSIR-CRI's mission is to develop and disseminate demand-driven technologies and build capacity for sustainable food and industrial crop productivity, with the vision to become a Centre of Excellence for agricultural research, innovation and capacity building for development.

The Institute's core mandate is to conduct research and develop improved varieties of food and industrial crops and their production technologies in order to enhance food security and eventually leading to poverty reduction. The relevant crops include: legumes (cowpea, soybean, groundnut, canning beans and bambara groundnut), cereals (maize and rice), roots and tubers (yam, cocoyam, cassava, taro and sweet potatoes), vegetables (pepper, garden eggs, tomato, onion, and leafy vegetables), tropical fruits (citrus, mango, avocado, cashew, pineapple, and pawpaw), and industrial crops (rubber and sugarcane).

With values such as Excellence, Fairness, Commitment, Transparency, Accountability and Teamwork at the heart of its operations, the Institute aims to

- develop and disseminate appropriate technologies that are demand driven and acceptable to end users.
- promote and strengthen strategic partnerships with relevant stakeholders to enhance the generation of solutions to challenges in agricultural research, technology development and transfer.
- improve institutional capability to undertake effective research and service delivery to enhance agricultural productivity.

- enhance research and technology delivery through efficient mobilization and management of funds
- improve the management and operating procedures and systems as a means of ensuring efficiency in research delivery.

In addition to its core mandate, the Institute also offers several services to various stakeholders. Thes include but are not limited to the production of breeder seeds for the National Seed Industry, the supply of healthy planting materials of citrus, avocado, mango, plantain and banana, the development of crop varieties for food and industrial uses, the establishment of farms (tree crop plantations), the integrated management of crop diseases and pests (including weeds), the production of extension materials and advise on the use of appropriate experimental designs for field studies.

EXECUTIVE SUMMARY

The CSIR-CRI annual report for 2020 is a summary of most of its achievements within the calendar year. As in usually the case every year, the Institute chalked several successes in 2020 and it is our hope that this continues in forthcoming years.

The year 2020 was a very challenging year for the Institute as the covid-19 pandemic and its attendant restrictions and protocols affected most of our research activities. A number of activities and stakeholder interactions were either put on hold or executed virtually.

In partnership with the CGIAR Excellence in Breeding (EiB) programme, the CSIR-Crops Research Institute has taken steps to modernize its rice breeding programme to become more effective in producing the rates of genetic gain and variety turnover needed to meet the needs of farmers. The system has benefitted from the EiB's system-level coordination, shared services, expert guidance, resources, and access to cutting-edge innovations. These and many other changes are making the CSIR-Crops Research Institute's rice breeding programme a model one in the sub-region. It is helping us to be more effective at increasing genetic gain on farmers' fields and thus helping Ghana to achieve the expected rice self-sufficiency.

In 2020, with funding from the Modernizing Agriculture in Ghana (MAG) project, early generation seeds of cassava, maize, rice, soybean and pepper were produced. Additionally, 1.5 tonnes of foundation seeds of rice varieties, CRI-AgraRice and CRI-Amankwatia were also produced. The Institute also produced ten thousand (10,000) sweetpotato vines for supply. Numerous stakeholders have also been trained on appropriate management practices for producing several crops.

The implementation of the Bui Hydroelectric Project, by the Bui Power Authority (BPA) in the Bono region of Ghana, resulted in the resettlement of some communities. The CSIR-Crops Research Institute was commissioned to propose a suitable irrigation infrastructure design suitable for all year-round vegetable farming on a proposed 200-ha plot of land located within the Bui community. The research team after several on-field visits and tests successfully suggested the sprinkler irrigation system which was then constructed and used for year-round vegetable farming by the affected persons.

In order to curtail sweetpotato cultivar decline, the Institute used tissue culture techniques (meristem-tip culture and thermotherapy) to facilitate the production of clean pre-basic seeds. In all, a total of 14,537 *in vitro* plantlets were produced for about ten different sweetpotato varieties. Additionally, close to 95, 000 cuttings have also been sold to several clients.

To boost the Institute's visibility, an online television platform, CRI-TV was set up to provide excellent content on research and development from the CSIR-CRI and other research institutes. Since its official introduction in July 2020, the platform has engaged several stakeholders on its various programmes such "The Project", "Weekly news", "Personalities of Science, "Women of Science" "Farmers' link", "The Young Agripreneur" among several others.

As its contribution towards the fight against the covid-19 pandemic, Mrs. Linda Abrokwah, a staff of the Institute, worked as a covid-19 frontline staff with the Kumasi Centre for Collaborative Research (KCCR), a biomedical research institute located at the Kwame Nkrumah University of Science and Technology, in Kumasi.

Staff attrition continues to be a major challenge the Institute faces. This has caused a major decline in staff strength.

The Institute continues to engage in various commercialization activities in order to generate funds internally. The production and onward sale of planting materials is the major component of the Institute's commercialization activities.

As members of the scientific and academic community, staff of the Institute continue to make their research findings available to the public by regularly publishing in peer-reviewed journals. In 2020, the Institute recorded over one hundred publications. These comprise refereed journal papers, conference papers, manuals, production guides, books, book chapters, posters, and technical reports

01 Modernizing Rice Breeding at CSIR-Crops Research Institute

Sponsor(s): IFAD/ Excellence in Breeding (EiB)

Plate 1: Rice Breeding Field At CSIR-Crops Research Institute

Breeding of crops in public research institutions generally lags in comparison to similar efforts in large multinationals that are also involved in crop improvement. Consequently, many farmers in the developing world lack access to varieties that satisfy their needs. To help solve this problem, the CGIAR Excellence in Breeding (EiB) programme was set up to help modernize breeding programmes in the public sector so they become more effective in producing the rates of genetic gain and variety turnover needed to meet the needs of farmers.

CGIAR Excellence in Breeding (EiB) is accelerating the modernization of crop breeding programs that serve farmers in low- and middle-income countries. To combat hunger, poverty and climate change, farmers need diverse and continually improving crop varieties. EiB provides system-level coordination, shared services, expert guidance, resources, and access to cutting-edge innovations to support CGIAR breeding programs to deliver on six funder requests.

The rice breeding programme of the Council for Scientific Industrial Research-Crops Research Institute (CSIR-CRI) was the first institute in Ghana to have gone through this modernization programme in Ghana. A baseline assessment of the Institute's breeding programme and station infrastructure was completed in January, 2020 and a customized improvement plan was developed. Through this plan, a product design team was formed comprising various actors along the value chain. The product design team defined the market segment as 'Aromatic Long Grain' with the lowland ecology (rainfed lowland and irrigated ecologies) being the target ecology for the country.

Plate 2: Some equipment being used by the Institute's rice breeding programme

Additionally, a product profile has also been defined to guide rice breeding activities at the Institute. Traits that were prioritized in the product profile comprised yield, fragrance, amylose content (which controls cooking and eating quality), rice yellow mottle virus and blast diseases, and drought. The product profile is aimed at replacing CRI-AgraRice which occupies about 70% of the area cultivated to rice in Ghana with superior varieties.

To meet this product target, a core elite aligned to the product profile was defined to be used for all new crosses henceforth. The DNA marker technology has been incorporated to improve selection accuracy and to eventually hasten the rice breeding cycle. Additionally, a high throughput SNP platform service operated by Intertek in Sweden was used to perform QTL profiling of core elite germplasm ensuring that only parents with desirable alleles are selected for crosses. “F1” plants from all crosses now undergo genotypic quality control/ quality assessment to confirm their true hybrid nature. The DNA marker-assisted selection (MAS) is used for forward breeding where the markers are used to identify lines with key traits at F2, and subsequent generations.

A marker-assisted backcross introgression programme is also underway to incorporate genes for RYMV and blast resistance into the backgrounds of all popular aromatic varieties in Ghana. This will hasten efforts at having disease resistant versions of popular aromatic varieties such *CRI-AgraRice*, *CRI-Amankwatia* and *Jasmine 85*.

To avoid labelling and transcribing errors and as such increasing selection accuracy, our breeding activities have been digitized by the introduction and use of packet and tag printers as well as handhelds and seed counters.

The use of rapid generation advance (RGA) screen houses helps to accommodate 2.5 cycles/year but the current capacity of RGA screen houses can only handle 5 crosses per year. Under our modernization programme, the RGA screenhouse will be expanded to manage at least 15 crosses annually. The screenhouse will also serve as a centralized line development facility for both CSIR-CRI and CSIR-SARI rice programmes. Our seed inventory and processing systems are also being is upgraded.

Plate 3: RGA Screenhouse at Fumesua

These and many other changes are making the CSIR-Crops Research Institute's rice breeding programme a model one in the sub-region. It is helping us to be more effective at increasing genetic gain on farmers' fields and thus helping Ghana to achieve the expected rice self-sufficiency.

Research Team: *Maxwell D. Asante, Kirpal Agyeman Ofosu, Phyllis Aculey, Daniel Gamenyah, Sober Ernest Boadu, Elizabeth Norkor Nartey*

02 Irrigation Infrastructure Design for Vegetable Farming

Sponsor(s): Bui Power Authority (BPA)

Plate 4: The Sprinkler Irrigation System

The implementation of the Bui Hydroelectric Project, by the Bui Power Authority (BPA) in the Bono region of Ghana, resulted in the resettlement of seven (7) communities with a total population of 1,216 people, referred to as Project Affected Persons (PAPs). The Authority has over the years implemented livelihood programs aimed at restoring and improving the economic wellbeing of the PAPs. However, the impact as envisaged to build the resilience of the PAPs economically and reduce their dependence on the Authority was not fully achieved.

A committee set up by the Authority, resulted in the creation and implementation of seventeen (17) business modules; one of which was the Vegetable Irrigation Module expected to benefit 146 PAPs. The implementation of the module required the BPA to develop an irrigation infrastructure with operational requirements for beneficiaries to undertake all-year-round vegetable farming in an economically viable way.

Consequently, the CSIR-Crops Research Institute was commissioned to propose a suitable irrigation infrastructure design suitable for all year round vegetable farming on a proposed 200-ha plot of land located within the Bui community.

Field and laboratory analyses were conducted on soil samples dug from various parts of the land and global positioning system (GPS) points recorded at each observation point. Profiles of the hydraulic properties of the soils, considering several parameters, were examined and the quality of irrigation water assessed. An impact assessment that sought to investigate the effect the irrigation system might have on the environment was also done.

The soil-water infiltration rate, a very key parameter in designing irrigation systems which indicates the soil's ability to allow water flow into and through the soil profile, was determined using the double ring infiltrometer and replicated twice.

Plate 5: Scientists from CSIR-CRI on site at Bui

To obtain accurate information on soil-hydraulic conductivity, an irrigation suitability map was designed based on factors such as infiltration rate, plant available water capacity (PAWC), organic matter concentration, moisture content, soil bulk density and elevation of the topography.

Results revealed that soils found at the site belonged to the "*Banda*" and "*Kolingu*" soil associations. Additionally, soil series encountered within the "*Banda*" association at the site were the "*Bofe*" and "*Bau*" series, whereas, within the "*Kolingu*" association, the "*Tanchera*", "*Kupla*" and "*Berenyasi*" series were encountered.

Based on all the laboratory analysis, examinations, surveys and focus group discussions, the sprinkler irrigation system was proposed by the Institute. Additionally, the Institute also proposed the construction of a medium-sized water reservoir at the proposed site to divert and hold water upstream. The sprinkler irrigation system will be constructed for all beneficiaries for all-year-round vegetable production.

Research Team: *S. K. Amponsah, P. Oteng-Darko, E. Bessah, E. Sekyi-Annan, A. Appiah, G. N. Boateng B. Sakyiamah*

03 Production of Early Generation Seeds

Sponsor(s): Modernizing Agriculture in Ghana (MAG)

The Modernizing Agriculture in Ghana (MAG) is a five-year Canadian Government sponsored programme that focuses attention on demand-driven research and alternative methods of extension delivery with the objective of increasing productivity through intensive farming. The CSIR-Crops Research Institute is responsible for four main activities under the "Support to agricultural research to strengthen agricultural extension services and improve agricultural productivity" component. In 2020, with funding from MAG, early generation seeds of cassava, maize, rice., soybean and pepper were produced. To promote the use of tissue culture generated cassava planting materials among farmers, a total of 3, 132 plants from fifteen (15) in vitro established cassava varieties indexed for the African Cassava Mosaic Virus (ACMV) were generated from tissue culture. Additionally, 1.5 tonnes of foundation seeds of rice varieties, *CRI-AgraRice* and *CRI-Amankwatia* were produced. Ten thousand (10,000) sweetpotato vines were also supplied to the Asuanse Agricultural station for further distribution to farmers in the Central region of Ghana. Several quantities of cassava, soybean and pepper were also produced under the MAG programme.

Research Team: *E. Baafi (PhD), E. Annan-Afful (PhD), M. D. Quain (PhD), R. Prempeh (PhD), V. Amankwaah (PhD), J. Manu-Aduening (PhD), A. Oppong (PhD), P. F. Ribeiro (PhD), K, Adofo (PhD), M. K. Osei (PhD), J. Gyau, O. Ohene Djan, P. Marno, K. Obeng Danquah, I. Osei Tutu, S. Gyasi Boakye, M. Opoku, P. Appiah-Danquah, L. Allotey, A. Nimo Bosompem, A. Achiaa Aboagye, T. A. Mensah, S. Fuseini*

04 Increasing Tomato Production in Ghana Through Provision of High Yielding Varieties and Better Agronomic Practices

Sponsor(s): KOPIA-Tomato

Tomatoes (*Solanum lycopersicum*) constitute about 38% of the vegetable budget in an average Ghanaian home. However, Ghana is a net importer of tomatoes. Thus, consumption of the crop has outweighed local production and the country is currently heavily dependent on importation of both fresh and processed tomatoes from countries such as Burkina Faso and China, leading to an ever increasing import bill. This is mainly due to very low yields farmers realise from their farms annually in spite of the country's potential and comparative advantage to produce the crop locally.

Despite the existence of improved varieties of the crop, farmers in Ghana continue to cultivate local varieties, most of which have very low yields and quality. The adoption of high-yielding improved tomato varieties with good adaptability to local conditions coupled with good agronomic practices have the potential of addressing this problem.

Plate 6: Improved tomato varieties introduced to farmers

The CSIR-Crops Research Institute in collaboration with the Korea Program on International Agriculture (KOPIA), seeks to increase tomato production in Ghana through the provision of high yielding varieties, better agronomic practices and improved technologies to help boost yields.

Seeds of three improved tomato varieties from the Institute were distributed to farmers to cultivate using a local variety as check. Farmers were supplied with inputs such as fertilizers in addition to technical assistance in field establishment and data collection. They were also trained on good agronomic practices associated with tomato production.

The tomato lines introduced to the farmers, *CRI-P005, CRI-P002* and *CRI-P068* produced an average yield of 20 tons per hectare after several marketable fruits were harvested. The obtained yields were more than double that obtained from the local check. The varieties are not only unique in terms of yield but also have good brix (suitable for processing), are early maturing and are also tolerant to tomato blight.

Economic analysis to determine the viability of the tomato lines for formal registration and release resulted in benefit cost ratios (BCR) of 3.49, 3.49 and 3.04 for *CRI-P005*, *CRI-P002* and *CRI-P068* respectively. These indicate that farmers will be better off economically cultivating the proposed genotypes (lines) when they are finally released as varieties. Additionally, gross margins for the proposed lines were also determined to be GHC17,189/ha (CRI-P005), GHC17,189.00/ha (CRI-P002), and GHC15,047.00/ha (*CRI-P068*); all of which were higher than that for the local check (GHC3,801.50/ha).

These genotypes will be proposed to the National Variety Release and Registration Committee (NVRRC) for registration and release as varieties.

Research Team: *M. K. Osei (PhD), B. Annor (PhD), J. Osei-Adu (PhD), K. A. Bediako (PhD), J. Gyau*

05 Sustainable Management of Diamondback Moth (DBM) and Whitefly On Cabbage

Sponsors: Modernizing Agriculture in Ghana (MAG)

Plate 7: An image of a Diamondback Moth

Cabbage, *Brassica oleracea* is an important temperate vegetable crop used in the preparation of several foods such as stews, salads and soups. It is also an excellent source of vitamin C and beta-carotene. As in other parts of the world, diseases and pests pose major biotic constraints to cabbage production in Ghana.

The diamondback moth (DBM), *Plutella xylostella L.* is the most important cabbage pest globally; responsible for causing up to 100 percent yield losses on affected fields. The total cost of management and yield losses associated with DBM globally is estimated at US $ 5 billion. The whitefly, *Bemisia tabaci* also poses problems to cabbage production in Ghana.

The application of synthetic insecticides, a strategy employed by most vegetable farmers globally, has been the major solution to managing these pests. However, limited knowledge in the handling and use of these insecticides by Ghanaian farmers, most of whom cannot read, write or understand labels, continues to be a major constraint in the successful implementation of this strategy in Ghana.

Additionally, demonstrations were held at various locations using six (6) different insecticides that had been tested in the laboratory in addition to a "no-insecticide" control. The insecticides used were *Bio T-Plus, Attack, Warrior Super, JMS Stylet, Dean* and *Cruzer*. Three fungicides, *Caldo Bordelės*, *Mancozeb* and *Carbendazim* were also applied to manage cabbage leaf blight. The insecticides were applied one week after seedlings were transplanted. This continued until cabbage heads were fully formed.

All six selected insecticides were very successful in managing Diamondback moth and whitefly attack in the selected districts. Farmers learnt in addition that, the wrongful application of the insecticides that they practised hitherto, could leave traces of the insecticides on the harvested product. These demonstrations will be replicated in several districts across the country to change farmers' attitudes towards the choice of insecticides and application procedures, eventually ensuring quality and insecticide-free cabbage production in Ghana.

Plate 9: A section of cabbage farmers who benefitted from the training

Research Team: *Blankson Wadie Amoabeng (PhD), Kofi Frimpong Anin (PhD) and Godfried Ohene Mensah*

06 Development of Rice Seed Multiplication and Dissemination System in Ghana

Sponsors: Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI)

Plate 10: Rice research fields at the CSIR-CRI, Fumesua

The huge gap between local consumption and production of rice continues to widen despite increased efforts by research institutes like the CSIR-Crops Research Institute at breeding several high-yielding improved varieties. This is attributable to factors such as low quality seeds, limited access to seeds of preferred and improved varieties, unpredictable weather conditions, low technical know-how in rice production as well as harvest and postharvest losses. The industry is also characterized by few certified seed growers making it difficult to multiply seeds in large quantities in order to meet the demand by farmers.

To address this, the Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI) is collaborating with the CSIR - Crops Research Institute to develop an efficient and sustainable model to enhance the multiplication and dissemination of rice seeds in Ghana. The project also hopes to strengthen any existing rice seed multiplication and dissemination system as well as train stakeholders in the rice value chain on multiplication and dissemination of rice seeds.

A baseline survey to identify and rank various constraints within the rice value chain, held in twelve (12) rice growing communities across three (3) districts in Ghana, listed credit, high cost of fertilizers, limited access to seeds of improved varieties and lack of storage facilities as the major constraints faced by farmers.

With 2.02 tons of breeder seeds produced from four elite varieties (*CRI-Dartey, CRI-Enapa, Amankwatia* and *Agra-Rice*) and almost 40 rice seed technical staff drawn from research institutions and the Ministry of Food and Agriculture (MOFA), trained in rice seed production and quality control techniques, the project is on course to achieving all set targets leading to the development of a more efficient seed multiplication and dissemination system in Ghana

Research Team: *Isaac Osei-Tutu, Maxwell D. Asante, Phyllis Aculey*

07 Next Generation Cassava Breeding

Sponsors: International Institute of Tropical Agriculture (IITA)

The Next Generation Cassava Breeding project (NextGen Cassava) is a Cornell-led international project with eleven (11) partner institutions across three different continents. The project seeks to modernize partner cassava breeding institutions in Africa such as the CSIR-Crops Research Institute, and use cutting-edge tools for efficient delivery of improved varieties of cassava. The ultimate beneficiaries of this project are the cassava farmers of sub-Saharan Africa, who will receive improved varieties that increase fresh root yields, are more resilient to devastating virus diseases, and exhibit other traits preferred by smallholder farmers.

NextGen is currently in its second 5-year phase and is supported by a grant from the Bill and Melinda Gates Foundation and UKaid from the UK government. Additionally, the project aims to improve cassava breeding by implementing a novel breeding method known as Genomic Selection, to increase growth cycles and improve information exchange between researchers and breeders. In this second phase, the project is expanding international efforts to deliver improved varieties of cassava to smallholder farmers in sub-Saharan Africa. The ultimate beneficiaries of this project are the cassava farmers of sub-Saharan Africa, who will receive improved varieties that increase fresh root yields, are more resilient to devastating virus diseases, and exhibit other traits preferred by smallholder farmers.

Over 500 million people in Africa consume cassava daily. Despite the importance of cassava for food security on the African continent, it has received relatively little research and development attention compared to other staples such as wheat, rice and maize. The key to unlocking the full potential of cassava lies largely in bringing cassava breeding into the 21st century. Consequently, the CSIR-Crops Research Institute has genotyped a total of 217 “genotypes” (made up of germplasm, advanced lines and released varieties) with two sets of molecular markers.

The first set was a Quality Control (QC) SNP Panel comprising 18 highly informative SNPs while the second was a trait-linked SNP panel with markers linked to cassava mosaic disease (CMD2) resistance, cassava green mite (CGM) resistance, provitamin A content and dry matter content.

Additionally, to build the capacity of staff on data management and analysis using appropriate statistical packages, the project organized a training workshop on the 'R' statistical software package for 27 participants comprising research scientists, technologists and technicians of the Institute with a facilitator from the International Institute of Tropical Agriculture (IITA). Using balanced formal and semi-formal approaches, participants were taken through installation of the software, typing in small datasets, assigning variables, concatenating datasets and combining variables with different functions.

Plate 11: Participants at the training workshop on the 'R' statistical software package

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08 Progress on the Second Phase of the West African Virus Epidemiology (WAVE) For Root and Tuber Crops Project

Sponsors: Bill and Melinda Gates Foundation (BMGF)

After a successful launch in the Gabonese capital of Libreville in 2019, the WAVE project, which is expected to build capacities of the participating countries to respond to threats posed by viral diseases of cassava and ensure food security in West and Central Africa has undertaken a nationwide cassava disease survey. The survey followed a harmonized protocol for data and sample collection developed for all participating countries of the WAVE project. The protocol involved collection and labelling of all viral-infected cassava leaves and stems. These were then kept on herbarium pressers and the labelled cuttings were maintained in the screenhouse. Infected leaves were sent to the laboratory for analysis and healthy cuttings were collected from every field for on-station evaluation. All data was collected using a programmed application developed by the Cambridge University, UK. Diseased leave samples are being analyzed using molecular primers and protocols adopted for all WAVE implementing countries.

In addition,viral disease distribution maps have been developed for Ghana. The second phase of the project is expected to end in 2023.

Plate 12: Viral strains detected in 2016 and 2017

Research Team: *Dr. Allen Oppong, Prof. J.N.L. Lamptey, Prof. M.B. Mochiah, Dr. Ruth Prempeh, Prof. Joe Manu Aduening, Linda Abrokwa, Esther Agyemang Marfo, Benedictta Nsiah Frimpong, Zipporah Appiah-Kubi, Augustine Agyekum, Kwasi Paul, Rose Osei, Peter Amoah, Prof. Stella A. Ennin*

09 Strengthening Sweetpotato Seed Systems for the Production of Clean Planting Materials for Diversified Markets

Sponsors: Sweetpotato Action for Security and Health in Africa (SASHA II)

Plate 13: Surface sterilization of shoot tips

Plate 14: Meristem excision and inoculation

Sweetpotato (*Ipomoea batatas L.*) plays a very vital role in food security in many countries with its area under cultivation expanding faster than that of other major food crops in Africa in the past decade. More than 24 million tons of sweetpotato are produced annually in South Saharan Africa. Sweetpotato is planted using vine cuttings that may be obtained from current crops on the field. Continuous cultivation of sweetpotato year in and out on farmers' fields could lead to cultivar decline due to biotic constraints including nematodes, viral diseases, soil arthropods, weevils, and foliage feeding insects.

The CSIR-Crops Research Institute is therefore using tissue culture techniques (meristem-tip culture and thermotherapy) to facilitate the production of clean pre-basic seeds after virus detection methods have been undertaken. Once varieties have undergone diagnostics and are declared virus free, they are multiplied in vitro for sale to farmers and commercial seed growers. Sweetpotato genotypes are acclimatized in pots at indexing screen houses and placed under double protection with regular watering for 3-4 months. Scoring of visual viral symptoms of the sweetpotato plants are then observed and scored. Three leaves of about 1.0-2.0 cm in length are then sampled from the top (near the meristem shoot point), the middle and close to the base along the length of the vines for each of the genotypes for nitrocellulose membranes enzyme-linked immunosorbent assays (NCM ELISA).

Plate 15: Sweetpotato seedlings produced via tissue culture techniques

The lines are surface-sterilized and initiated in vitro using meristem tip culture technique. Cultures are incubated under a dark phase in a controlled climate chamber at 23-25°C for 14 days and later exposed to normal growth conditions of photoperiod of 16 hours of light and 8 hours of darkness. Non-infected genotypes are multiplied *in vitro* and acclimatized at the screen house.

In 2020, a total of 14,537 *in vitro* plantlets were produced for about ten different sweetpotato varieties including *CRI-Apomuden*, *CRI-Bohye* and *CRI-Nan*. A total of 5,490 plantlets were hardened and planted in new chamber. Additionally, close to 95, 000 cuttings have been sold to several clients.

In vitro regeneration techniques play a major role in the sweetpotato production system since techniques such as meristem tip culture have the advantage of producing disease-free planting materials. The use of the temporary immersion bioreactor system (TIBS) for sweetpotato in the tissue culture laboratory has helped improve the multiplication rates of different varieties leading to an increase *in vitro* based cultures available for hardening and screen house multiplication. Plants regenerated from successful meristem tip cultures have a very high chance of testing negative for the commonly known viruses that cause sweetpotato virus disease (SPVD).

Research Team: *Marian D. Quain, Kwadwo Adofo, Patricia P. Acheampong, Peter Amoah, Emmanuel Digooh, Boadi Ahenkorah, David Pukinka, Dr. Victor A. Amankwaah, Godfred Osei Kwame, Agnes Achiaa Aboagye, Michael Arthur, David Pukinka*

10 Managing Fall Army Worm with the Push-Pull Technology: Are there benefits to the soil?

Sponsors: CSIR-Crops Research Institute

Since its introduction three seasons ago, successes from the "push-pull" strategy in controlling fall armyworms (FAW), have been recorded at the CSIR-Crops Research Institute. The "push-pull" system with various temporal and spatial arrangements has been found to suppress fall armyworm (FAW) infestation while increasing the population of beneficial arthropods for maize production. However, the effect of this integrated plant management (IPM) strategy on the soils, needs to be evaluated.

Since "push-pull" is a crop diversification strategy that involves the use of legumes, it is important to quantify the benefits the soil, and consequently, the crops obtain from the system in order to boost the possibility of adaptation by farmers. Additionally, it is important to consider the fertility of the soil in order not to cause further decline to our already nutrient-deficient soil. Desmodium (*Desmodium intorum*), the "push" factor usually used in this strategy is a legume which is not only beneficial to the soil but also limits the ability of the pests to locate the maize plants and repels them with plant-mediated chemicals. To determine the effect of the crop components of the push-pull system on the soil, the hypothesis that Desmodium may increase soil fertility but including it in the system with maize, a heavy feeder, would offset its beneficial effects in the long run was made. Nitrates, ammonium and microbial biomass carbon levels were then evaluated.

Plate 16: The "push-pull" technology being implemented on the field

Using a randomized complete block experimental design with three replications, contents of organic matter, nitrogen, phosphorus and potassium as well as soil moisture and soil PH were analyzed. The soil was also analyzed for nitrates (NO_3^-), ammonium (NH_4^+) and microbial biomass carbon (MBC).

Results not only showed that Desmodium fixes nitrogen into the soil to improve soil nitrogen concentrations, but also confirmed that microbial soil benefits increase with more Desmodium population per land area. Hence, aside effectively controlling the FAW in the push-pull systems, Desmodium is also a good companion crop candidate which improves soil nitrogen concentration for maize use. It also has the potential to enhance soil microbial activity.

Research Team: *Dr. Mavis Badu-Brempong, Dr. Stephen Yeboah, Dr. Patricia Oteng-Darko, Mrs. Abigail Addo-Danso*

11 Training on Processing and Utilization of Released Common Bean (*Phaseolus sp.*) Varieties

Sponsors: Pan-Africa Bean Research Alliance (PABRA)

Processing parameters for novel product concepts (meat substitutes, baked beans and vegetarian milk) from common bean (*Phaseolus sp.*) have been developed for the Institute's released varieties and fine-for consumer acceptabilty. With support from the PABRA project, A one-day training workshop was organised to train processors and representatives from various institutions, who would also serve as potential trainers. The training was intended to create awareness and demand for such products, in promoting the use of the beans.

Participants from various institutions were given hands-on training in the processing of innovative products from common bean. The potential contribution of these released common bean (Phaseolus sp.) to Ghana's food industry, and also in the sustainable alleviation of micronutrient deficiencies, was also highlighted.

Plate 17: Participants at the workshop being trained in the preparation of innovative products from common bean

Research Team:

Dr. Evelyn Adu-Kwarteng, Mrs. Faustina Okyere, Ms. Abigail Amoa-Owusu

12 Knowledge Exchange Activity - Tomato Research

Sponsors: GCRF, UK

As part of a demonstration trial held to disseminate the tomato partial rootzone drying technology conducted at the CSIR-Crops Research Institute, relevant stakeholders were invited to participate in a two-day knowledge exchange event at the Akumadan Irrigation Scheme. The Akumadan Irrigation Scheme is one of the 57 irrigation schemes developed by the Ghana Irrigation Development Authority (GIDA) across the country. The scheme is well-Plate 18: Participants on the field during the trainingknown for the mass production of tomato and vegetable crops in the country.

Plate 18: Participants on the field during the training

Farmers and stakeholders were trained on raising beds and furrows for planting tomato seedlings as well as the installation of pipes for the furrow system. Participants were also taken through good agronomic practices associated with planting tomato, scheduling irrigation, operating the furrow irrigation and maintaining plots and irrigation systems. At the end of the workshop, farmers expressed great satisfaction with the simplicity and cost-effectiveness of the irrigation system and the convenience its use would provide.

Research Team: *Ing Dr Patricia Oteng-Darko, Dr Stephen Yeboah, Dr Ebenezer Annan-Afful, Dr Joseph Adomako, Dr Stella Ama Ennin, Dr Benjamin Annor*

13 Training on the Management of rice diseases

Sponsors: Modernizing Agriculture in Ghana (MAG)

In order to build the capacity of district development officers at the department of agriculture in the Ashanti and Ahafo regions to further train agricultural extension agents and farmers in the management of rice diseases, a two-day training of trainers' workshop was organized for such officers managing rice disease verification trials in the Ashanti region. Forty-four (44) participants, comprising 38 males and 6 females were trained on various areas such as causes of rice diseases, types of diseases and disorders, disease triangle, disease cycle, diagnosis, and management of major rice diseases. Other areas treated included the role of arthropods in rice production, the life cycle of insects, rice insect pests and their management, natural enemies of rice insect pests, site selection, habitat manipulation/land preparation, as well as the use of improved varieties and fertilizer management. Practical sessions where participants visited various rice fields in the districts and not only identified and diagnosed various rice diseases but also recommended treatments were also undertaken.

Plate 19: Participants on the field during the training

Research Team: *Godfried Ohene-Mensah, Dr. Kofi Frimpong-Anin, Mr. William Lelabi Kota*

PUBLICIZING RESEARCH ACTIVITIES TO ENHANCE TECHNOLOGY TRANSFER

The Public Relations Unit of the Institute facilitated several media engagements, with the objective of increasing the Institute's visibility and keeping stakeholders and the public informed about its activities. Scientists participated in agricultural radio discussions to share information on research programmes.

Plate 20: Images of some CRI media engagements in 2020

2020 CSIR-CRI MEDIA ENGAGEMENTS

TITLE OF PUBLICATION	MEDIA ORGANIZATION	DATE OF PUBLICATION
The fig tree at Wiamoase: CSIR-Crops Research Institute explains	www.myjoyonline.com	21st May, 2020
Scientists identify species of tree erroneously linked to apple	www.gna.org.gh	22nd May, 2020
The apple fever gripping Ghana lately: Maybe....just maybe	Joy FM News	29th May, 2020
CSIR College of Science and Technology graduates first batch of students	JoyNews	29th July, 2020
CSIR-CRI provides research, technical expertise to enhance MAG programme	www.ghanabusinessnews.com	15th September, 2020
Agriculture to receive boost as CSIR-CRI produces sufficient planting materials	www.myjoyonline.com	27th September, 2020
Crop research scientists, extension officers assess laboratory-tested insecticides	www.gna.org.gh/ www.ghanaweb.com	15th December, 2020
Rice self sufficiency: Farmers Farmers happy with CRI new rice varieties	www.myjoyonline.com	25th December, 2020
Boost for rice production: CSIR introduces new drought and disease resistant varieties	TV3 News	31st December, 2020

The Institute is also very active on various social media platforms such as Facebook, Twitter, and YouTube where several of the institute's research activities are published.

CSIR-CRI INTRODUCES CRI-TV

Over the years, several research outputs and technologies have been developed by the various institutes of the CSIR as well as most public and private tertiary institutions in Ghana. Nonetheless, the uptake of these research outputs is still limited partly due to the lack of information and exposure on these outputs. It is this gap" that CRI TV has come to fill.

CRI TV is an online TV platform aimed at providing viewers with excellent content on research and development from the CSIR-CRI and other research institutes. Additionally, the platform also engages in several developmental and social issues that have a direct or indirect impact on research outputs. Since its official introduction in July, 2020, the platform has engaged several stakeholders on its various programmes such "The Project", "Weekly news", "Personalities of Science, "Women of Science" "Farmers' link", "The Young Agripreneur" among several others. Like its tag line, CRI-TV aims to take viewers and the public "**beyond the research**" so they can actually see and experience the literal impact of our technologies.

COMMERCIALIZATION ACTIVITIES

Plate 21: Some products available at the commercialization division of the Institute

The Institute has a division responsible for driving its commercial activities to enhance its income generating capacity and speed up the dissemination and transfer of its technologies through several activities. These commercial activities comprise production activities such as the sale of improved varieties of planting materials (seeds and seedlings), farm produce and fruits from the Institute's orchards and plantations.

In 2020, production activities included the production of planting materials under the Planting for Food and Jobs (PFJ) and the Planting for Export and Rural Development (PERD) programmes. In all, a total of 36,000 seedlings of mango, citrus, coconut, and avocado pear were produced by the Institute in 2020.

DONOR SUPPORT IN 2020

With no research support from the Government of Ghana, the Institute continues to receive funding for all its research projects from both local and international funding agencies. In 2020, sponsors such as Solidaridad, the Centre for Agriculture and Bioscience International (CABI), the Alliance for a Green Revolution Africa (AGRA), the Bill/Melinda Gates Foundation (BMGF), KAFACI International, the International Institute of Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT), the African Agricultural Technology Foundation (AATF), KOPIA and the Modernizing Agriculture in Ghana (MAG) secretariat were the major donors to the Institute.

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1. *Evaluation of rice lines from Korea for their reaction to rice yellow mottle virus disease resistance in Ghana*

Authors: *Asante, M.D., Braima, A. Oppong, A., Traore, V.S.E., Adebayo, M.A., Aculey, P., Marfo, E.A., and Kyung-Ho, K.*

Rice yellow mottle virus (RYMV) is the most damaging viral disease of rice in Africa and can cause yield losses of up to 100%. The objective of this study was to characterize newly introduced rice lines from Korea into Ghana for their reaction to RYMV infection. One hundred and seventy-two rice lines from Korea were screened for their level of resistance RYMV in a screen house at Fumesua, Ghana. Four checks consisting of two highly resistant lines (Tog7291 and Gigante with *rymv1-2* (resistant gene1-allele2) and *rymv2* (resistant gene2) respectively), a moderately resistant line (CRI-Amankwatia) and a susceptible cultivar Jasmine 85 were used. The experiment was carried out in a 4 x 44 lattice design with four replicates. Screening for RYMV resistance was conducted by visual symptom scoring and virus-assessment through serology using enzyme linked immunosorbent assay (ELISA) test. Disease incidence and severity were assessed from 2 to 42 dpi. Data for disease severity and incidence were transformed (Log x+1) for ANOVA. Five lines (8261112, 8261119, 8261133, 8261588, and 8261634) were identified to be highly resistant to the disease just like Tog7291 and Gigante. The study also revealed 24 lines that were resistant but not grouping with Tog7291 and Gigante, whereas 100 moderately resistant lines clustered with the moderately resistance check CRI-Amankwatia in a distinct group. Forty-three (43) susceptible lines were identified with the susceptible check Jasmine 85 falling in this group. No highly susceptible line was identified. The newly idenfied resistant genotypes can be used by breeders to develop RYMV resistant varieties

2. *Plant-parasitic nematodes associated with sweet potato rhizosphere soil in the Semi- Deciduous Forest and Coastal Savannah Zones of Ghana*

***Authors**: Adomako, J., Danso, Y., Sakyiamah, B., Kankam, F and Osei, K.*

A survey was conducted in nine major sweet potato producing districts across the semideciduous forest and coastal savannah zones of Ghana to determine the prevalence of plantparasitic nematodes parasitizing the crop. Soil samples were collected at 90-days after planting from the rhizosphere of sweet potato crop and analysed using Modified Baermann tray method from 100 farms across the study area. Seven plant-parasitic nematode genera were extracted from soil samples collected and morphologically identified under a microscope with four of them, namely Meloidogyne, Pratylenchus, Rotylenchulus, and Helicotylenchus being the most prevalent. Scutellonema sp. occurred in 89% while Tylenchus sp. occurred in 33% of the districts sampled. The ring nematode, Criconemella sp. was found in only two of the nine districts covered; Ketu North and Akatsi South which incidentally recorded 100% of the seven nematodes encountered in the survey. The abundant nematode was Meloidogyne sp. which represented 39% and Criconemella, the least (0.1%) of the total nematodes recovered in the survey. This study has shown that high diversity, incidence and density of economically important plant-parasitic nematodes are associated with sweet potato crop. Development of appropriate management strategies to mitigate the negative effects of plant-parasitic nematodes on sweet potato is recommended.

3. *Simulative evaluation of the response of maize and some dual-purpose legumes to water and nutrient amendments.*

Authors: *Oteng-Darko P., Yeboah S., Agyei Obeng E.., Amponsah W., Ennin S. A.,Sarpong F., Owusu Danquah E., Adomako J., Acheampong L. D., Agyeman K., and Addo-Danso A.*

The study evaluated DSSAT's CERES-Maize and CROPGRO models for their effectiveness insimulating the growth of maize, groundnut, and cowpea under dynamic nutrient amendments andwater management practices in field experiments. The experiments were laid-out in split-plotwith water management (rainfed and irrigated) as main plots and fertilizer (organic andinorganic fertilizer) as sub-plots during the maize trial, while, water management treatment(irrigated and rainfed) was the main plot and variety as the subplot during the cowpea andgroundnut trials arranged in three replications.

The CERES-Maize model's RMSE-observationsstandard deviation ratio (RSR) for simulating maize grain yield under irrigated and rainfed were0.1624 and 0.0317 respectively, while that for the maize biomass under irrigated and rainfedwere 0.4027 and 2.1676 respectively. Also, the CROPGRO model's RSR for simulatinggroundnut grain yield under irrigated and rainfed were 0.1058 and 8.0592 respectively, whilethat for the groundnut biomass under irrigated and rainfed were 1.1154 and 0.0161 respectively.In addition, the CROPGRO model's RSR for simulating cowpea grain yield under irrigated andrainfed were 8.1625 and 0.1019 respectively, while that for the cowpea biomass under irrigatedand rainfed were 0.2677 and 0.2630 respectively. From the results, it was concluded that theCERES-Maize model was more suited to effectively scope alternate management practices undermaize production whereas more research is needed to be able to confirm the effectiveness of the model in our environment.

4. *Yield and cost of biochar produced by a locally fabricated reactor*

Authors: *Akom, M., Fanyin - Martin, A., Oti-Boateng, C., Otoo, E., and Dawoe, E.*

This study examines the yield and cost of biochar produced using a locally developed reactor. Biochar yield of 540 kg was obtained from 1460 kg of wood shaving feedstock used. The average charring ratio and feedstock were 37% and122 kg respectively. A total of 988 kg of firewood was used to produce the biochar in 35 days. The total cost of production was GH¢ 1214.42 (USD 631.49) with an average of GH¢ 4.99 (USD 2.59), GH¢ 20.58 (USD 10.70), GH¢ 26.52 (USD 13.79) and GH¢ 19.95 (USD 10.37) spent on feedstock, firewood, transportation and labour per day respectively. It is suggested that locally manufactured reactor should address heat loss issues as well as improve heat capture system. The facility should also be sited near the source of feedstock as much as possible to reduce transportation cost. It is also recommended that the price of biochar should be subsidized once it has an established market.

5. *Economic analysis of seed yam production in aeroponics system. Implications on employment and food security in Ghana*

Authors: *Acheampong, P. P., Quain, M. D., Appiah-Kubi, D., Osei-Adu, J., Ennin, S. A.and Osei, K.*

Yam is traditionally propagated vegetatively by means of the edible tuber. This practice is associated with low multiplication rate (less than 1:10), long dormant phase of the tuber prior to sprouting and planting materials that are infested with pathogens. The aeroponic production of seed yam in Ghana is seen as the way forward to solving planting material acquisition menace. The 'aeroponics system' is means of growing plants with nutrient water in a soil-less environment. The multiplication rate of seed yam in aeroponic system is as high as 1:70 and more. The system has been perceived as expensive for any individual to undertake. However, it is thought to be a very lucrative business venture for production of high quality seeds for both local consumption and export. To encourage private sector participation in this venture economic analysis to determine the feasibility and viability of the aeroponic system is necessary.

6. Demonstrating the efficacy of existing yam technologies in the Forest – Savannah transition zone of Ghana.

Authors: *Frimpong, F., Owusu Danquah, E., Aidoo, A. K., Ennin, S. A., Asumadu, H., Maroya, N.*

Improved technologies (row planting, ridging, seed treatment, weed management, fertilizer application) with a proven record of sustained productivity for yam production are imperative for food security. This study promotes the efficacy of these existing improved agronomic practices using a farmer-based participatory approach in some selected major yam-growing areas in the forest-savannah transition zone of Ghana. The improved agronomic practice treatment included use of ridging as seedbed, seed treatment before planting, fertilizer application at a rate of 30:30:36 N:P2O5: K2O kg/ha plus 15 kg/ha Mg and 20 kg/ha S as MgSO4 and the use of minimum stakes (trellis; 30-50% fewer stakes used by farmers).

This was compared with farmers' practice, which consisted of mounding, no fertilizer application, and no seed treatment. A significantly ($p \leq 0.01$) higher yam yields (more than 60%) were observed for the improved agronomic practice over the farmers' practice at Ejura, Atebubu, and Kintampo which are major yam-growing communities of Ghana. Sensory evaluation showed that the culinary quality of fertilized yam was as good as unfertilized yam. The contribution of existing improved yam production practices in the selected yam communities of Ghana was quantified in terms of their productivity and economic benefit to smallholder farmers.

7. Gene action of shelf-life and other fruit quality traits in a cross between a regular cultivar and alc mutant of tomato

Authors: *Osei, M.K., Danquah, A., Danquah, E., Blay, E. and Adu-Dapaah, H.*

Prolonged shelf-life and good quality fruit are crucial attributes for the marketing of tomato (Solanum lycopersicum L) and thus a major focus for breeding. This study was carried out to explore gene effects, heritability, heterosis and inbreeding depression for shelf-life, fruit quality and some quantitative traits of tomato using six generations derived from a cross between CSIR/CRI-P002 (P1) an adapted variety with good yield and short shelf-life, and Alc-LA3134 (P2), a ripening mutant tomato with long shelf-life but low yield. The P1 , P2 , F1 , F2 , BC1.1, BC1.2 generations were subjected to generation mean analysis. Mean performance of the F was higher 1 than the mid-parent for all traits except total soluble solids (TSS). Additive and dominance variances were higher than environmental variance for all traits. Apart from shelf-life, the simple additive-dominance (three-parameter) model was inadequate for explaining the gene action for the traits. Using the six parameter model, additive, dominance and epistatic gene effects were found to be significant for most of the studied traits. Duplicate epistasis was detected for all the traits except shelf life. The fixable and non-fixable gene effects exhibited by the traits can be improved through pure line breeding and heterosis, respectively.

ISSN 2590-9606

Design & Print : 2P Koncept - 0246774334